THURSDAY, SEPTEMBER 16, 1886

EARTHQUAKE DISTRIBUTION

Alphabetical Catalogue of the Earthquakes recorded as having occurred in Europe and adjacent Countries arranged to serve as a basis for an Earthquake Map of Europe. By Joseph P. O'Reilly, C.E., Professor of Mining and Mineralogy, Royal College of Science, Dublin. *Transactions* of the Royal Irish Academy, Vol. XXVIII. "*Science.*" (Dublin, 1886.)

THE distribution of earthquakes may be studied either geographically or topographically—either along its broad lines in connection with the general physics of the globe, or in its smaller details with immediate and minute reference to local peculiarities. The field of inquiry is in both directions vast and comparatively unexplored. As regards what we may call circumstantial seismography, little has been done in the particular application of general principles to explain the apparent caprices of disturbances. These are innumerable and fantastic; yet, by patient observation, they can to a certain extent be brought within the range of strict physical reasoning. The laws of wave-motion, taken in connection with the facts of geological formation, will account for a good deal. Not, however, for all. Subterranean agencies introduce an element of uncertainty into the calculation which no diligence or ingenuity avails wholly to eliminate. Thus, in South America certain districts are observed to remain year after year, perhaps century after century, unscathed amid surrounding devastation. They are hence called "bridges," the disturbance seeming, as it were, to flow beneath them, like a river under a bridge. Prof. Milne suggests that their immunity may be due to the total reflection of earth-vibrations which would otherwise reach them ("Earthquakes," p. 141). An obstacle to the propagation of such is besides often interposed by faults and fissures. The partial repose of Quito is attributed to the frequency of cañons in its vicinity; as, similarly, the Capitol of Rome and the citadel of Capua were said to be protected by numerous deep wells or springs sunk round them.

"Bridges," however, cannot invariably be depended upon. Their privilege of safety is liable at any moment to be withdrawn. The peninsula of Caraya, for instance, forming the northern shore of the Gulf of Cariaco, was never known to be shaken until December 14, 1797; yet it has since had its full share of disturbance. The interior arrangement of strata was here doubtless subverted, and the barrier to the extension of shocks from the chalk-hills of the mainland to the slate-rocks of the opposite peninsula overthrown, by the violence of the blow which destroyed Cumana. Centres of disturbance, too, shift and travel in a way to defy anticipation; and the effects of the interference of earth-waves, to which some terrific catastrophes, as well as many apparent anomalies of rest or commotion, are ascribed, can rarely be calculated beforehand. Nevertheless, much knowledge of high value, both practical and theoretical, might be acquired by the continuous topographical study of earthquakes in countries exposed to their ravages. Prof. Milne states that in Japan (where, through his initiative, more has been done in this branch than in any other part of the world), although earthquakes occur there at the average rate of two a day, yet with proper care a building site may be chosen as free from shocks as if it were situated in Great Britain.

The publication now under review is, however, directed to a different and a wider purpose. Prof. O'Reilly had already compiled a "Catalogue of Earthquakes" for these islands (see NATURE, vol. xxxi. p. 351); he has now accomplished a similar task for the whole of Europe with the outlying districts along the Mediterranean and Black Sea shores, designed to form the basis of a map showing the larger geognostic relations of these phenomena. Without some such picture, he rightly observes, no geological map should be regarded as complete. The latter displays results; the former represents the forces at work to produce them. The importance of earthquakes in geological history is great and far-reaching. Their connection with the physical structure of a country is most intimate. Every one of its leading features is related to them, either causally or consequentially. The main lines of jointing and fissuring, with the inseparably associated strike of coast-lines, are, according to a view originated by our author, directly conditioned by the prevailing direction of earthquake shocks. Its correctness can be tested only by statistical inquiries such as those of which he here gives us a laborious example. Other questions of interest awaiting similar elucidation relate to seismic action with reference to coal-fields and to the progress of elevation or subsidence.

Fuchs gives many instances of shocks limited to or originating in carboniferous districts ("Vulkane und Erdbeben," p. 196), and explains them by the progressive decomposition of organic matters quickened by the admission of air in working the shafts. The resulting escape of fire-damp diminishes the volume of the beds; they give way with a concussion, and an earthquake ensues. Extremely curious, in this connection, is the close agreement between the curves denoting the monthly frequency of earthquakes and of colliery explosions pointed out by Prof. O'Reilly (*Trans.* R. Irish Academy, vol. xxviii. p. 297). Each shows a strong and precisely coincident maximum in March, while the earthquake maximum in November is less perfectly matched by a conspicuous increase, one month later, in the number of explosions. The analogy of the equinoctial maxima of auroræ and magnetic disturbances cannot fail to suggest itself; and there are other indications that seismic and magnetic perturbations are not wholly extraneous to each other. Both auroræ and earthquakes, for instance, distinctly gain in frequency during the half-year which includes our winter season and the perihelion passage of the earth; and there have been too many and too close coincidences between their occurrences to be purely accidental.

Sudden changes of level, especially depressions, are an ordinary concomitant of earthquakes. An internal collapse of the strata in some cases produces the shock; in others the shock ruptures supports or overturns foundations long unsound. Degradation by water has perhaps undermined them; contractions have taken place through cooling, through chemical action, possibly through slow evaporation. At last a crash comes, and a tract of land, deprived all at once of its insecure props, settles down to a lower level, a forest perhaps subsiding into a lake, or the sea over-washing a stretch of shore.

Slower processes of change, however, are probably far more general and effective, and with these seismic relations are still in part obscure. Such changes depend, there is little doubt, upon variations of equilibrium between internal forces of expansion and external forces of repression. Where these are accurately balanced, the bounding surface of the earth remains unaltered; where subterranean heat gets the better of gravity, as through the denudation of large tracts, elevation ensues; where the weight of the superincumbent strata is augmented by deposition, there is slow subsidence. The effects of the earth's secular cooling must evidently, in the long run, be thrown wholly into the scale for contraction; and yet it is to them indirectly that the upthrusting of mountain-ranges is due. These might be compared to the folds and creases of a garment grown too ample for the shrunken body it covers. The terrestrial crust, indeed, is less easily adaptable than an old coat; not a wrinkle in it but represents a series of paroxysms, every one implying a greater or less amount of earth-shaking, past and present. The snap after prolonged strain, the shifting and twisting of rocks, the fissuring and faulting, the slipping and wrenching and grinding of tormented strata in the effort to satisfy the stresses put upon them, all result in earthquake action of the mechanical kind. Thus, mountain-making is essentially a seismic operation, not only while in progress, but in its effects during long subsequent millenniums. This is one chief reason why the lines of earthquake distribution follow so faithfully the general direction of mountain-ranges.

But besides those commotions which result from the catastrophic restoration of disturbed equilibrium, there are earthquakes of the volcanic or explosive class. This species has been defined as an "uncompleted effort to establish a volcano." Such abortive eruptions are occasioned, there is much reason to suppose, by the sudden formation of steam at great depths beneath the earth's surface. They arise where broken and disjointed strata facilitate the percolation of water to volcanic foci. A fractured crust and a plentiful aqueous store are their developing conditions. Hence their frequentation of sea-coasts. Prof. Milne remarks that most Japanese earthquakes originate in the Pacific, and that the steepest coasts are, on the whole, the most severely shaken; as is easily intelligible when we consider the violence of the dislocations necessary to produce them.

Earthquakes may then be broadly distributed, according to their kind, into two systems, now coalescing, now independent of each other. The explosive species follow volcanoes along sea-coasts, the mechanical sort are associated with mountain-ranges; all attend lines of weakness, and are more or less closely connected with the shrinkage by cooling of the terrestrial crust. Thus, every volcanic region is liable to earthquakes; though there are earth-shaken districts which are not volcanic.

The tendency to alignment in volcanoes has often been noticed: Prof. O'Reilly indicates a similar peculiarity in earthquakes, adding that the lines along which they range commonly approximate to great circles. This inference, or suspicion, can be verified only by detailed charting. There are great difficulties, however, in getting a true graphical representation of seismic activity. Not only deficiencies in records have to be contended with, but grave perplexities as to their treatment. They are fully admitted by our author. The number of shocks felt in a given spot is the criterion inevitably adopted; but these may vary to any extent in intensity, or may be the mere sympathetic reverberation of some distant catastrophe. The Lisbon earthquake of 1755, for instance, may quite possibly have shaken every square foot of the globe. The ideal seismic map would be one of earthquake origins, with their attendant areas of disturbance; but this is at present far from being attainable; and we can only acknowledge the indebtedness of science to those indefatigable workers who, like Prof. O'Reilly, promote knowledge by the best *present* means open to them.

OUR BOOK SHELF

Department of Agriculture, Washington: Third Report on the Chemical Composition and Physical Properties of American Cereals, Wheat, Oats, Barley, and Rye. By Clifford Richardson. (Washington, 1886.)

THIS Report is an important continuation of a most valuable work. The object in view is to obtain accurate information respecting the composition of the cereal grains produced in the various States. The grain analysed is in some cases the produce of seed issued by the Agricultural Department, but generally represents the ordinary crops of the district. A complete physical and chemical examination has been made of each sample of grain: the results are tabulated under the head of the State in which the grain was reared. The Report contains 77 analyses of different varieties of wheat grown in Colorado; 179 analyses of the kernel of oats, and 100 analyses of the husk; 57 analyses of rye, and 72 of barley. The extent of variation in composition, the relation of physical characters to chemical composition, and the influence of climate, are discussed. The results are further compared with those obtained by investigations in Europe. At the close of the Report are given some detailed analyses of cereal grains in which sugar, starch, and the albuminoids soluble and insoluble in alcohol, are separately determined. Analyses are also given of the very various products obtained from wheat by roller-milling. The whole is a magnificent contribution to the history of cereals. We now know far more of the characteristics of cereals grown on the American continent than we do of those produced in the United Kingdom. When will an English Agricultural Department inaugurate a similar study?

As we have no space for the details of the results, it is perhaps hardly fair to criticise. We would merely remark that dextrin is not reckoned by the best modern chemists among the constituents of barley, or of other cereal grains that have been thoroughly investigated. The method used for determining starch is apparently one yielding too high results, while the "fibre" shown in the analyses is far below the total cellulose and incrusting matter really present. We call attention to these errors of method, as they are very generally met with, and it is high time that they were remedied. R. W.

Longmans' School Geography. By George G. Chisholm, M.A., B.Sc. (London: Longmans, Green, and Co., 1886.)

ONE point which the recent discussions with regard to geographical education in this country has brought out